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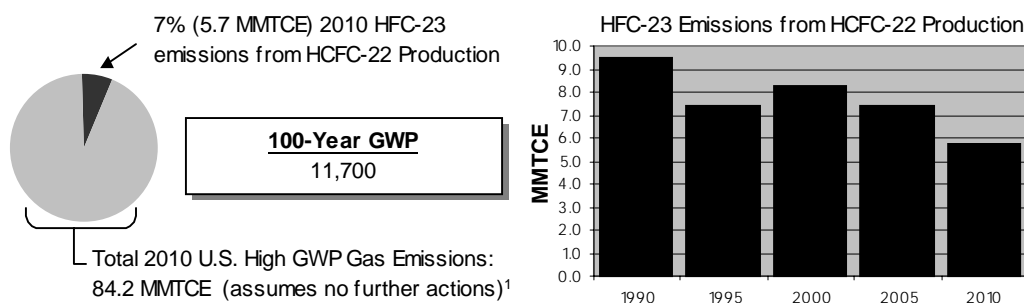
## 2. Cost and Emission Reduction Analysis of HFC-23 Emissions from HCFC-22 Production in the United States

### 2.1 Introduction

Trifluoromethane (HFC-23 or  $\text{CHF}_3$ ) has a 100-year global warming potential (GWP) that is 11,700 times greater than the warming potential of carbon dioxide over the same period. HFC-23 is generated as a byproduct during the production of chlorodifluoromethane (HCFC-22), currently used in refrigeration and air-conditioning systems and as a chemical feedstock for manufacturing synthetic polymers. Under a business-as-usual scenario (i.e., no actions), by 2010, HCFC-22 production in the United States would be expected to emit approximately 5.7 million metric tons carbon equivalent (MMTCE) of HFC-23 (see Exhibit 2.1).<sup>1</sup> However, actual emissions are expected to be lower, in part as a result of emission mitigation actions by industry that are not included in the business-as-usual baseline. Current and potential applications for HCFC-22 include:

- **Aerosol propellants**, as alternatives to CFC-12 in a few permitted uses;
- **Foam blowing**, as an alternative to CFC-12 in polyurethane foams and in polystyrene extruded boardstock and billet;
- **Refrigeration**, as an alternative to R-502 (a blend of CFC-115 and HCFC-22) in most cooling systems, air-conditioning systems, heat pumps, and in blends to replace other CFCs in various cooling systems (Heijnes *et al.*, 1998); and
- **Tetrafluoroethylene manufacture**, as a feedstock used in the process of tetrafluoroethylene production.

Exhibit 2.1: U.S. Historical and Baseline HFC-23 Emissions from HCFC-22 Production



<sup>1</sup> An explanation of the business-as-usual scenario under which baseline emissions are estimated appears in the Introduction to the Report.

Under the Clean Air Act, manufacture and import of HCFC-22, except for use as a feedstock and in equipment manufactured before 2010, are scheduled to be phased out by January 1, 2010. All manufacture and import except for chemical feedstocks is scheduled to be phased out by January 1, 2020. Four U.S. companies account for approximately 39 percent of all global and 100 percent of U.S. HCFC-22 production: Allied Signal, Inc.; DuPont; MDA Manufacturing; and ATOFINA-North America (Rand *et al.*, 1999).

Manufacturers of HCFC-22 in the United States are voluntarily working to reduce emissions of HFC-23 that are generated as a byproduct of HCFC-22 manufacture (Exhibit 2.1). Under this program, U.S. manufacturers have pledged to reduce HFC-23 emissions from HCFC-22 manufacturing by 4.1 MMTCE by 2000 through the use of cost-effective mitigation measures (DOS, 1999; Bernhardt, 2000).

## 2.2 Historical and Baseline HFC-23 Emission Estimates

Historical emissions of HFC-23 from HCFC-22 production are shown in Exhibit 2.2, and include emission reductions seen under the HCFC-22 CCAP Program. To estimate future baseline emissions (for the years 2000, 2005, and 2010), EPA assumes that future average HFC-23 emission factors will remain constant at an average of 1995-97 levels and HCFC-22 production will initially increase and then decline as non-feedstock HCFC production is phased out. Future baseline emission estimates do not include CCAP program reductions (see Exhibit 2.3).

**Exhibit 2.2: Historical U.S. HFC-23 Emissions from HCFC-22 Production (1990-1999)**

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
<b>Emissions (MMTCE)</b>	9.5	8.4	9.5	8.7	8.6	7.4	8.5	8.2	10.9	8.3
<b>Emissions (metric tons HFC-23)</b>	2,974	2,632	2,974	2,726	2,692	2,316	2,667	2,573	3,419	2,598

Source: EPA, 2001.

Note: Conversion to MMTCE is based on a GWP of 11,700.

**Exhibit 2.3: Baseline U.S. HFC-23 Emissions from HCFC-22 Production (2000-2010)**

	2000	2005	2010
<b>Emissions (MMTCE)</b>	8.2	7.4	5.7
<b>Emissions (metric tons HFC-23)</b>	2,583	2,313	1,790

Notes:

Forecast emissions are based on a business-as-usual scenario, assuming no further action.

Conversion to MMTCE is based on a GWP of 11,700.

## 2.3 HFC-23 Emission Reduction Opportunities

Historically, a majority of HFC-23 emissions were vented to the atmosphere. However, two options have been identified as technically viable measures to reduce HFC-23 emissions from HCFC-22 production: (1) manufacturing process optimization, and (2) the destruction of HFC-23 by thermal oxidation (March Consulting Group, 1998; March Consulting Group, 1999).

### **Process Optimization**

Process optimization and modifying production equipment can both optimize HCFC-22 production and reduce HFC-23 emissions. Process optimization is relatively inexpensive and is likely to be most effective in reducing the emissions from plants that are generating HFC-23 at a rate of three to four percent. All plants in the United

States have already implemented some optimization resulting in reductions of HFC-23 emissions. These plants may achieve further reductions through further process optimizations, but these reductions are likely to be more modest (Rand *et al.*, 1999).

### Thermal Oxidation

Thermal oxidation (the process of oxidizing HFC-23 to CO<sub>2</sub>, hydrogen fluoride (HF), and water) is a demonstrated technology for the destruction of halogenated organic compounds. For example, destruction of more than 99 percent of HFC-23 can be achieved under optimal conditions (i.e., a relatively concentrated HFC-23 vent stream with a low flow rate) (Rand *et al.*, 1999). In practice, units will experience some downtime based on the extreme corrosivity and high temperatures required for complete destruction. Although typical incinerators that burn only HFC-23 produce six pounds of CO<sub>2</sub> for every one pound of HFC-23 burned, almost all of the CO<sub>2</sub> produced is prevented from entering the atmosphere by scrubbers in the smoke stack. This reduction in CO<sub>2</sub> emissions occurs while scrubbing to remove HF from the waste stream (Oldach, 2000).

## 2.4 Cost Analysis

Thermal oxidation is an effective mitigation measure to reduce HFC-23 emissions. It has been estimated that the total installed capital costs for a thermal oxidation system are approximately \$7 million per plant with total annual operational costs of \$200,000 per year (Honeywell, 2000). Some U.S. plants have already started to use this technology; the installation of such systems for other plants is technologically feasible. Cost estimates for such systems are based upon the best available industry assessments and actual costs of some systems could differ from these estimates.

Exhibit 2.4 presents a summary of HFC-23 emission reductions from thermal oxidation at both four and eight percent discount rates by cost per metric ton of carbon equivalent (TCE). At the four percent discount rate, thermal oxidation measures could be implemented at an estimated \$0.64 per TCE, thereby eliminating nearly all baseline emissions at a relatively low cost.

Exhibit 2.4: Emission Reductions and Cost in 2010						
Option	Break-even Cost (\$/TCE)		Incremental Reductions		Sum of Reductions	
	Discount Rate					
	4%	8%	MMTCE	Percent	MMTCE	Percent
Thermal Oxidation	0.64	0.73	5.7	99.9%	5.7	99.9%
Notes:						
2010 Baseline emissions from this sector equal 5.7 MMTCE.						
Conversion to MMTCE is based on a GWP of 11,700.						
Sums might not add to total due to rounding.						

## 2.5 References

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